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Paper review: Learning functionals via LSTM neural networks for predicting vessel dynamics in extreme sea states

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Predicting motions of vessels in extreme sea states represents one of the most challenging problems in naval hydrodynamics. It involves computing complex nonlinear wave-body interactions, hence taxing heavily computational resources. Here, we put forward a new simulation paradigm by training recurrent type neural networks (RNNs) that take as input the stochastic wave elevation at a certain sea state and output the main vessel motions, e.g., pitch, heave and roll. We first compare the performance of standard RNNs versus GRU and LSTM neural networks (NNs) and show that LSTM NNs lead to the best performance. We then examine the testing error of two representative vessels, a catamaran in sea state 1 and a battleship in sea state 8. We demonstrate that good accuracy is achieved for both cases in predicting the vessel motions for unseen wave elevations. We train the NNs with expensive CFD simulations offline, but upon training, the prediction of the vessel dynamics online can be obtained at a fraction of a second. This work is motivated by the universal approximation theorem for functionals [1], and it is the first implementation of such theory to realistic engineering problems.